Journal of Data Acquisition and Processing
ISSN: 1004-9037
https://sjcjycl.cn/
DOI: 10.5281/zenodo.7766190

APPEARANCE FEATURES BASED HYBRID METHOD FOR ROBUST FACE RECOGNITION

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Abstract: Face recognition systems have become increasingly important in many applications including security, surveillance, access control, identity verification, and human-computer interaction. One of the primary objectives of a face recognition system is to identify individuals from their facial features. This can be used to authenticate the identity of an individual or to detect a known individual in a crowd. Another objective is to verify the identity of an individual based on their facial features. This can be used for access control or to confirm the identity of an individual for various purposes such as financial transactions, travel, and other secure applications. Face recognition systems can improve security by automatically identifying and flagging individuals who pose a threat. This can be useful in public spaces, airports, border control, and other high-security areas. Face recognition systems can also provide convenience in various applications such as unlocking a device or accessing a secure area without the need for physical keys or passwords.

Accuracy of face recognition is affected by various challenges in input images such as occlusion, pose, aging, expression, low resolution, and illumination variation. This proposed work aims to examine and overcome the substantial difficulties in transferring current facial recognition algorithms to the real world. Here methodological approaches used for the proposed model are the viola-jones algorithm with haar cascade, grey level co-occurrence matrix, gabor filter, cross- validation, and support vector machine. After applying the above methods at various stages of the face recognition process; the proposed model provides a person's identity with high accuracy on standard video datasets and many standard image datasets.
Keywords: Computer vision, Face recognition, Face detection, Cross validation, Support vector machine

1. Introduction

Biometrics and face recognition are based on a distinct and specialized form of personal identity. To provide recognizable evidence, this process totally depends on matching the image with other individual images [1]. Facial recognition has recently taken on increased significance in smart cities. Traditional computer methods are no longer suitable for complex applications which require feature extraction [2].

The face is the most crucial biometrics due to its significance in the construction of person's identity [3]. The main objective of face recognition system is to identify a person from photos and video source. Numerous difficulties affect how well the face verification system performs. As a pre-processing stage, a median filter, a Gabor filter, and histogram equalization are employed [4].The Facial Recognition System is a technique that recognizes people in digital photos using a number of algorithms [5]. Motion- based object detection includes face detection as well. It investigates a person's behavioral and physiological traits. When compared to other methods like fingerprint and iris recognition, face recognition system require less time and human interaction for verification [6]. To perform well in face recognition, a large training sample is typically needed. Back- propagation will be hampered and non- representative embeddings will be produced if the same person is carelessly treated as different classes in several datasets [7]. Main phases of face recognition system are Face detection, feature extraction, and face classification [6]. The face detector locates the face by analyzing every element of the image.

Face detection is an important step in face recognition; however, identifying faces can be difficult due to a variety of factors on the face, such as skin texture, skin tone, face shape, glasses or beard wear, head posture, facial expression, and lighting conditions [8]. Reducing the rate of misstatement is the primary objective of facial recognition. Numerous sectors that necessitate more complex computations for face detection use facial recognition.

Overall, the importance of face recognition systems lies in their ability to improve security, simplify identification and verification processes, and enhance the user experience in a variety of application.

2. Literature Review

This section covers a short introduction of the most well-known as well as widely used facial recognition techniques, as well as systematic classifications. Real-time surveillance systems heavily rely on face recognition [8]. Biometrics and face recognition are based on a distinct and specialized form of personal identity. To create a recognised pattern, this process entirely depends on matching the image with other distinct images. The optimal method for performing the correlation is to select facial characteristics from both the image and a facial database [1]. The application of deep learning for facial identification using unreliable facial signals is explored in article [9]. The results show that when the proportion of the face decreases, the recognition rate seems to perform poorly. The eyes, however, appear to convey more recognition even in automated facial recognition. CS measurement dramatically improves classification performance over linear and kernel SVMs. It is preferable to avoid strongly turned faces. Faces have been rotated between 110 and 120 degrees since it appears that they perform badly in recognition tests, as illustrated by an example.

State-of-the-art face recognition systems [6] give adequate effect only under supervised conditions. When faced with real-world situations, they become significantly less. This paper analyses the most fortunate algorithms as well as what has been accomplished so far. It also generated a number of potential avenues for facial recognition in the future. One of the most important human biometrics is the face, which forms an important role in the drafting of identity and emotions. No technique is able to equalize the human ability to acknowledge faces, even with the many changes in appearance that the face can have in a scene. Reference [3] has presented the various problems in depth that may arise in a facial recognition system.

The basic goal of every face recognition system is to recognise a human from static images and video sequence. This overview [10] highlights the main applications, challenges, and advancements of face recognition systems in the social and scientific fields. The illumination challenge is shown in the paper [11] with a mask over its face. Because of unhealthy habits, unfavourable attitudes, or people's innate fragility, many people are not appropriately wearing their masks. In this situation, the applied mask-to-face deformable model is presented globally to allow the production of further masked face images, particularly with specialised masks. Then, for a variety of applications, the Masked Face-Net technique can be utilized to improve vision-based monitoring systems. Due to the widespread use of many sensors, cross-modality facial recognition [12] is another newly emerging area. More than 10,000 pictures of 113 people in more than 15 different countries are included in the Tufts Face Database. The availability of this database to the general public will allow for the evaluation of face recognition techniques using multimodal photos. The face conveys a person's identity and emotions, it is most important in social interaction. Face recognition systems [13] are the most accurate types of biometrics available. Future work will focus on improving face detection in conditions like facial occlusion and poor illumination.

Numerous difficulties affect how well the face verification system performs. The median filter, Gabor filter, and histogram equalisation are used as pre- processing steps. To extract feature vectors, the Principal Component Analysis (PCA) [4] approach is employed. According to experimental findings, in various lighting situations, face recognition accuracy is effectively boosted. A well-known vision library, OpenCV (Open-Source Computer Vision) [14], was founded by Intel in 1999. OpenCV 2.3.1's programming interface is available for C, C++, Python, and Android programmers to use. Taxonomy of facial recognition methods that use both video and images is given in [15]. The effectiveness of the face verification method is affected by a number of issues. The median filter, Gabor filter, and histogram equalisation are used as pre-processing steps. To extract feature vectors, the Principal Component Analysis (PCA) [4] approach is employed. According to experimental findings, in various lighting situations, face recognition accuracy is effectively boosted. A well-known vision library, OpenCV (Open- Source Computer Vision) [14], was founded by Intel in 1999. OpenCV 2.3.1's programming interface is available for C, C++, Python, and Android programmers to use.

Viola-Jones model is one of the best-known and often used object detectors. The detector is capable of detecting faces efficiently [16]. Paul Viola and Michael Jones created the Viola-Jones facial detection algorithm. The Viola-Jones approach fails to correctly recognise faces when there are stiff objects in the face image [17], such as chopsticks, because its features can't handle totally rigid objects. The purpose of the study [18] is to establish the ideal spacing for a CCTV camera installation in a passenger inspection area at an airport. The training data consists of images from five different viewpoints, whilst the testing data includes video. The outcome reveals that a 300 cm distance yields the maximum accuracy rating of 86.76 percent. Motion-based object detection includes face detection as well. This study [19] focuses on the most promising methods for identifying faces against complex backdrops and in other difficult situations. To perform well in face recognition, a large training sample is typically needed. Back-propagation will be hampered and non-representative embeddings will be produced if the same person is carelessly treated as different classes in several datasets [7].

3. Flow of Face Recognition Process

Process of face recognition is combination of different methods. Whole process can be done with various methodologies. Mainly face recognition is divided into many parts, as shown in Fig. 1. Image has to pass through every part of the process.

In the first step, the target images are taken from the input source, which can be either static photos or video streaming, at this initial stage of the face recognition system. A picture pre-processing enables exact results and noise avoidance. The system must overcome various obstacles that could hinder the process overall, particularly in an unrestricted environment. These obstacles could include changing image background, pose variation, age variation, expression, and illumination change [10].

In face recognition system one of the main phase is Face detection. Its aim is to identify that image contains actual face image or not. Detection of faces from image is shown in Fig. 2. The Viola-Jones face detection algorithm [5], principle component analysis (PCA) [15] and the histogram of oriented gradient (HOG) [17] are just a few of the methods or approaches that can be used to identify a human face. The next step in analyzing an image is to extract the facial features. As seen in Fig. 3, the structure, size, and individual facial characteristics such as the mouth, eyes, and nose for identification [2].

At this stage, the features from the backdrop that were retrieved during the feature extraction step are taken into account and compared to known faces that are kept in a particular database. In this stage, the features that were disabled while the feature was running are taken into consideration. A test face is compared against a group of faces during the facial recognition step in an effort to identify the most probable. It is well known that k-nearest neighbours (K-NN) and convolutional neural networks (CNN) can successfully complete this task. [2].

Facial verification is known as one to one match problem. By matching it to the facial information of the claimed identification in the database, the identity of the query face image is either verified or rejected. [9].

Face Recognition system has to face many challenges that can occur due to variations in input image dataset. It is very difficult to detect and recognize the face from such input image. Major challenges found in input image are mentioned in following sections.

A. Occlusion

Some items may partially conceal faces. As seen in Fig. 4, some faces or other items in a group of people may partly obscure other faces, making only a portion of the face visible in many circumstances. This makes it difficult for the system to locate faces and even when faces are located, recognition is still challenging [6].

B. Illumination

Illumination means variation of light in the image [3]. As shown in Fig. 5, changes in illumination can also have an impact on the image because of how the skin reflects light and the camera's internal controls. When two photos of the same person are shot under different lighting conditions, the difference is higher than when two photos of two different persons are taken under the same lighting conditions. [10].

Fig. 2. Face Detection [20]

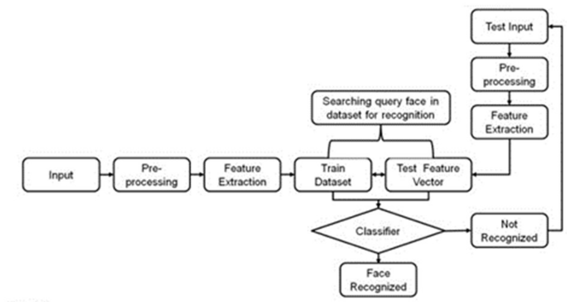


Fig. 1. Generalized Face Recognition Process

C. Pose

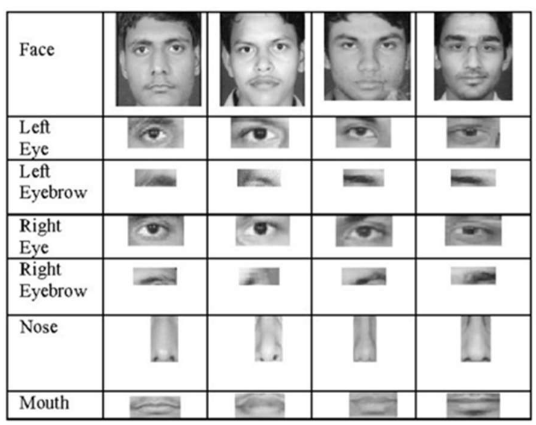


Fig. 3. Features Extraction [14]

4. Challenges in Face Recognition

Face recognition systems need to take into account image poses as well. The head's rotation position and viewing angle affect how a face is posed. These changes in posture hit hard problem for identifying the input image [3]. Fig. 6 illustrates different pose angles.

D. Expression

Face expression plays a major role in the transmission of emotions and human identity. The expression on a person's face has a direct impact on how their face looks. There are different facial expressions can be of human face like happy, sad, fear, anger, surprised, etc are shown in below Fig. 7.

E. Low Resolution

The image can't be detected properly if the resolution of the picture is not clear. It also forms a challenge in face recognition [3]. The example of low- resolution challenge can be CCTV camera captured image displayed in Fig. 8. CCTV camera with low resolution can't capture the clear image of the person. So, recognition of human face becomes difficult and challenging.

Fig. 4. Occlusion Effects [9]

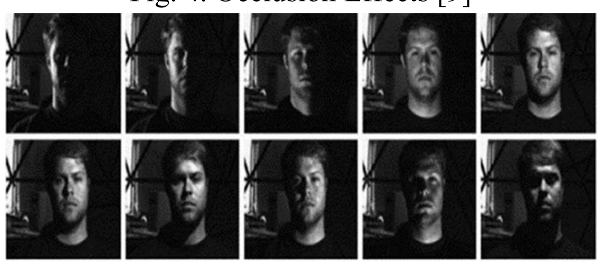


Fig. 5. Illumination Variation [9]

Fig. 6. Pose Variations [3]

Fig. 7. Facial Expression [21]

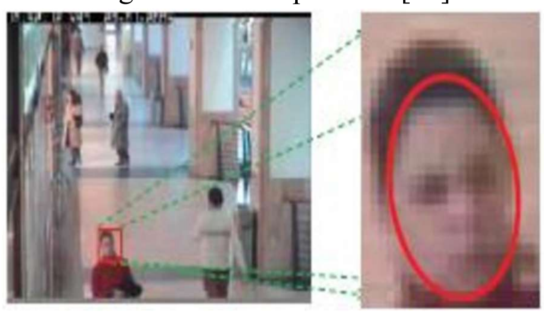


Fig. 8. Low Resolution [3]

F. Ageing

Recent have identified, "aging" as a big challenging problem in face recognition systems. This is obvious and unavoidable challenge due to age-related facial appearance changes, which create major variations in human face characteristics among images captured at different ages of the same person as shown in Fig. 9.

Fig. 9. Ageing Variation [21]

G. Similar Faces Identificarion

Twins or similar faces shown in Fig.10 made a big problem for face detection assertion structures that cannot choose the characters of the twin precisely. Baseline test for any face evidence estimate due to the close proximity between the face pictures [15]. Thus, it is very difficult for a recognition system to identify them.

Fig. 10. Similar Faces [2]

5. Face Recognition Approaches

Throughout the past three decades, several research communities, including those in machine learning, computer vision, and image processing have focused on the critical subject of facial recognition. It is challenging to create a distinct line that divides these approaches into standardised categories because the methods presented for facial recognition fall under broad and different scientific domains. It is additionally challenging to classify these approaches into typical branches for the representation or categorization of attributes due to the use of hybrid models [10]. The current methods for facial recognition are enumerated in Fig. 11.

Traditional facial recognition techniques span a wide range of fields and are widely dispersed. Classical face recognition approaches can be performed and evaluated using different methods and datasets. Few well known available methods to follow this approach [10] are Viola-Jones, SVM, PCA, Eigen face, LDA, SLDA, NMF, K-PCA, K-LDA, and Laplacian faces.

When using classification approaches, it is advantageous to employ local features-based methods and hybrid methods to handle various lighting situations, facial expressions, and other significant obstacles. They have comparatively lower noise and translation invariance sensitivity.

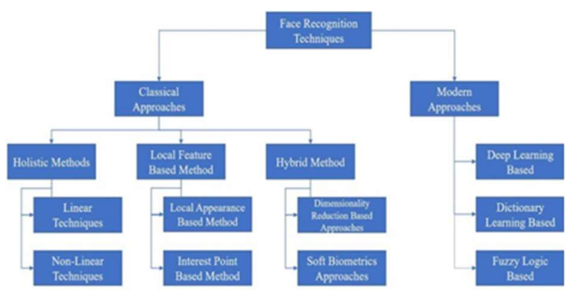


Fig. 11. Face Recognition Approaches

As presented in Fig. 11, Modern approaches of face recognition can have three methods. First method is Deep Learning based method. Deep learning-based methodology has attracted a lot of research attention in recent years. In the study [10], it was found that academic literature hardly ever discussed the use of intermediate visual features in convolutional neural networks to describe visual attributes. Dictionary- based learning is the second approach. It has been noted [10] that dictionary learning models and sparse coding have an impact on the methods currently used for face recognition. The third technique is based on fuzzy logic. Fuzzy-based approaches show great promise for resolving challenging face recognition problems, particularly those including lighting and position variability.

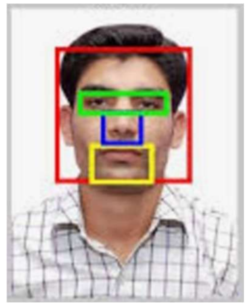


Fig. 122. Eyes, Nose and Face Detection using Viola- Jones

6. Proposed Approach

As shown in the Fig. 13, first step of our Proposed Methodology is to take the input data from various image datasets either existing or manually created. It is the very important part of any system.

Once the input is given, step by step process followed in proposed model is mentioned.

a) After taking input image dataset, the first step would include pre-processing, this step ensures bringing all the input images/dataset in same domain e.g. size, RGB/Gray, De-noising etc.

b) Then face detection is carried out by viola-jones algorithm with haar cascade. As a result eyes, nose and face from given input image portion is identified and selected from given input image as shown in Fig. 12.

c) Apply multiple features extraction process using Gabor and Gray Level Co-occurance Matrix (GLCM) to detected face portion that gives rich features matrix.

d) Cross validation is then used to obtain training and testing dataset and is fed to machine learning.

e) Now, we can use test image from used datasets or use any human face image. Then model will apply step (a) to (c) for that image and features matrix is generated for input image.

f) The Support Vector Machine (SVM) classifier is finally used for classification, and if a face is recognised based on a comparison and match of the best features matrix, it will produce a labelled-face.

7. Implementation Details

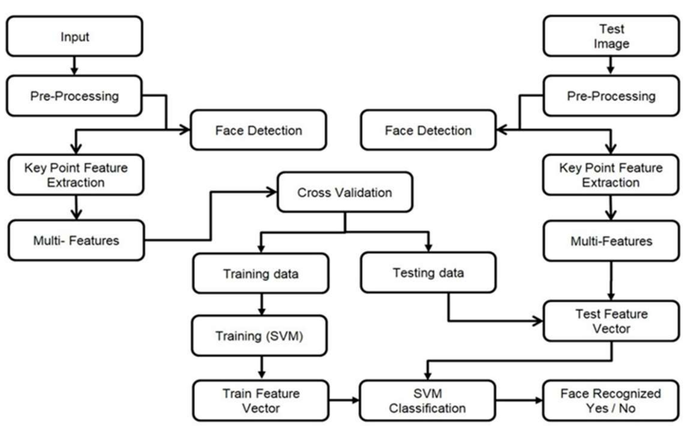


Fig. 13. Proposed Approach

Fig. 14 shows that face region is detected after clicking on test input button. This detection is

For numerous types of pattern analysis in various
fields, input data is a crucial component. In particular, it is crucial for face detection and face recognition. Here we have tested the model on YALE, ORL, JAFFE, Celeb 1000 and YouTube Faces video dataset. The PC used for the experimental analysis has an Intel Core i7 Processor running at 2.6GHz, 8GB of RAM and Matlab 2017b is used as a software platform.

performed using Viola-Jones face detection algorithm.
Fig. 15 shows that after the input test image and test image feature vector are formed. By pressing classification tab, features of test image are compared with that of the trained features and the best match is retrieved with name label.

Fig. 16 shows the result of trained Yale dataset with epoch steps. It's showing the value of loss and accuracy for each epoch.

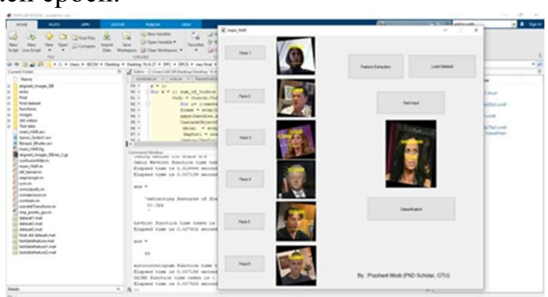


Fig. 14. Face Detection on Test Face Image

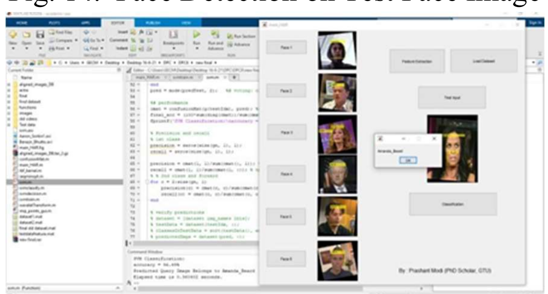
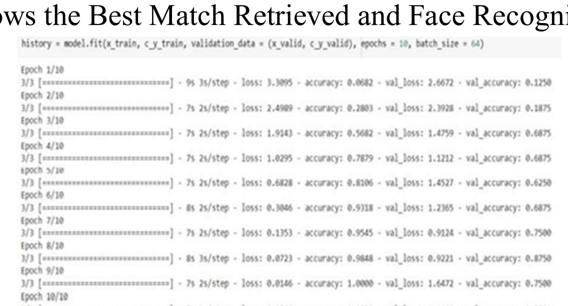


Fig. 135. Figure Shows the Best Match Retrieved and Face Recognized with Name Label



```
history = model.fit(x_train, c_y_train, validation_data = (x_valid, c_y_valid), epochs = 10, batch_size = 64)

Epoch 1/10
3/3 [==============================] - 9s 3s/step - loss: 3.3095 - accuracy: 0.0682 - val_loss: 2.6672 - val_accuracy: 0.1250
Epoch 2/10
3/3 [==============================] - 7s 2s/step - loss: 2.4989 - accuracy: 0.2803 - val_loss: 2.3928 - val_accuracy: 0.1875
Epoch 3/10
3/3 [==============================] - 7s 2s/step - loss: 1.9143 - accuracy: 0.5682 - val_loss: 1.4759 - val_accuracy: 0.6875
Epoch 4/10
3/3 [==============================] - 7s 2s/step - loss: 1.0295 - accuracy: 0.7879 - val_loss: 1.1212 - val_accuracy: 0.6875
Epoch 5/10
3/3 [==============================] - 7s 2s/step - loss: 0.6828 - accuracy: 0.8106 - val_loss: 1.4527 - val_accuracy: 0.6250
Epoch 6/10
3/3 [==============================] - 8s 2s/step - loss: 0.3046 - accuracy: 0.9318 - val_loss: 1.2365 - val_accuracy: 0.6875
Epoch 7/10
3/3 [==============================] - 7s 2s/step - loss: 0.1353 - accuracy: 0.9545 - val_loss: 0.9124 - val_accuracy: 0.7500
Epoch 8/10
3/3 [==============================] - 8s 3s/step - loss: 0.0723 - accuracy: 0.9848 - val_loss: 0.9221 - val_accuracy: 0.8750
Epoch 9/10
3/3 [==============================] - 7s 2s/step - loss: 0.0146 - accuracy: 1.0000 - val_loss: 1.6472 - val_accuracy: 0.7500
Epoch 10/10
3/3 [==============================] - 7s 2s/step - loss: 0.0566 - accuracy: 0.9773 - val_loss: 1.0688 - val_accuracy: 0.7500
```

Fig. 16. Results of Training the Yale Dataset

8. Results and analysis

Tab. 1. shows feature's combination and accuracy analysis for GLCM, Gabor and combination of both of them. We can observe from table that significant improvement seen in accuracy has been achieved for combination of GLCM and Gabor for feature extraction.

Accuracy and processing time analysis for different datasets for proposed model is presented in Tab. 2. The detailed classification accuracy report indicates good accuracy for proposed method. Fig. 17 shows graphical analysis for accuracy achieved for different datasets. Fig. 18 shows graphical analysis for recognition time spent (in seconds) for different datasets. It clearly shows that our proposed model is taking very less time for classification for all datasets.

Tab. 3. indicates comparative analysis of accuracy achieved for other research works with proposed method. Observation clearly shows that our proposed method is providing better accuracy. Fig. 19 present accuracy comparison analysis for all these research work in graphical form indicating proposed work accuracy is remarkable achievement.

Tab. 1. Feature's Combination and Accuracy Analysis

Combination of Features	Processing Time(s)	Accuracy[a] % (SVM)	Accuracy[a] % (Cross Validation + SVM)
GLCM	0.2744	92.67	92.93
Gabor	0.3997	94.85	94.90
GLCM + Gabor (Scale=5, Orientation=8)	0.5390	96.65	96.93

a. Average accuracy of all datasets used.

Tab. 2. Accuracy and Processing Time Analysis for different Datasets

Dataset	Recognition Time	Accuracy (%)
Youtube Faces	1.77 sec	96.43
Celeb 1000	2.12 sec	96.81
JAFFE	1.26 sec	98.81
Yale	1.92 sec	96.24
ORL	2.56 sec	96.37

Fig. 17. Accuracy of Proposed Approach for different Datasets

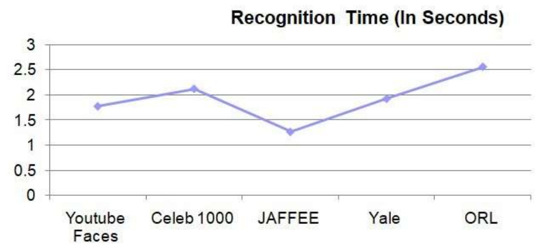


Fig. 18. Recognition Time of Proposed Approach for different Datasets

Tab. 3. Comparative Analysis of Accuracy with Proposed Method

Sr No	Literature	Methodological Approach	Database	Accuracy (%)
1	M. Da'san et al.[22]	Principal Component Analysis Viola and Jones Method Gabor Filters Artficial Neural Networks	Yale CMU	90.31%
2	Triantafyllidou et al. [23]	Convolutional Neural Network	Jaffe FDDB	88.9%
3	Vikram et al. [24]	Viola-Jones Algorithm	ORL Youtube faces	92%
4	Sharma, Sudha et al. [25]	Linear Discriminant Analysis Principal Component Analysis Naïve Bayes Multilayer Perceptron Support Vector Machine	ORL	96%
5	Matin et al.[26]	Principal Component Analysis Eigenface	Face94 ORL	92.5%
6	M. M. Sani et al.[27]	Principal Component Analysis Support Vector Machine Multiclass SVM	YALE	84%
7	Wang W. et al. [28]	Convolutional Neural Network Deep learning	LFW ORL	81%

8	Proposed Method	Viola-Jones Algorithm, Gabor + GLCM, Cross Validation Support Vector Machine	Youtube faces ORL Jaffee Yale	96.93%

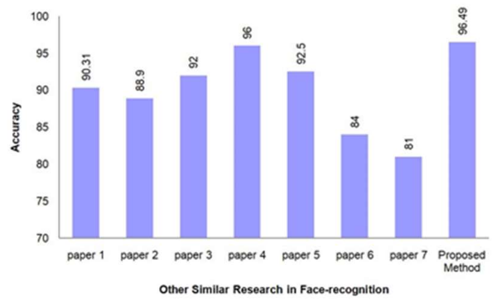


Fig. 19. Comparative Analysis of Accuracy with Proposed Method

9. Conclusion

In comparison to current state-of-the-art methods, the proposed system appears to be excellent, having good accuracy of 96.93% and requiring less processing time (0.539 seconds). The proposed model is a good break through for existing applications that uses face as a biometric measure for recognition. This combination of hybrid feature extraction methods and classifier have significantly reduce the processing time and provides high accuracy with challenging input test images.

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